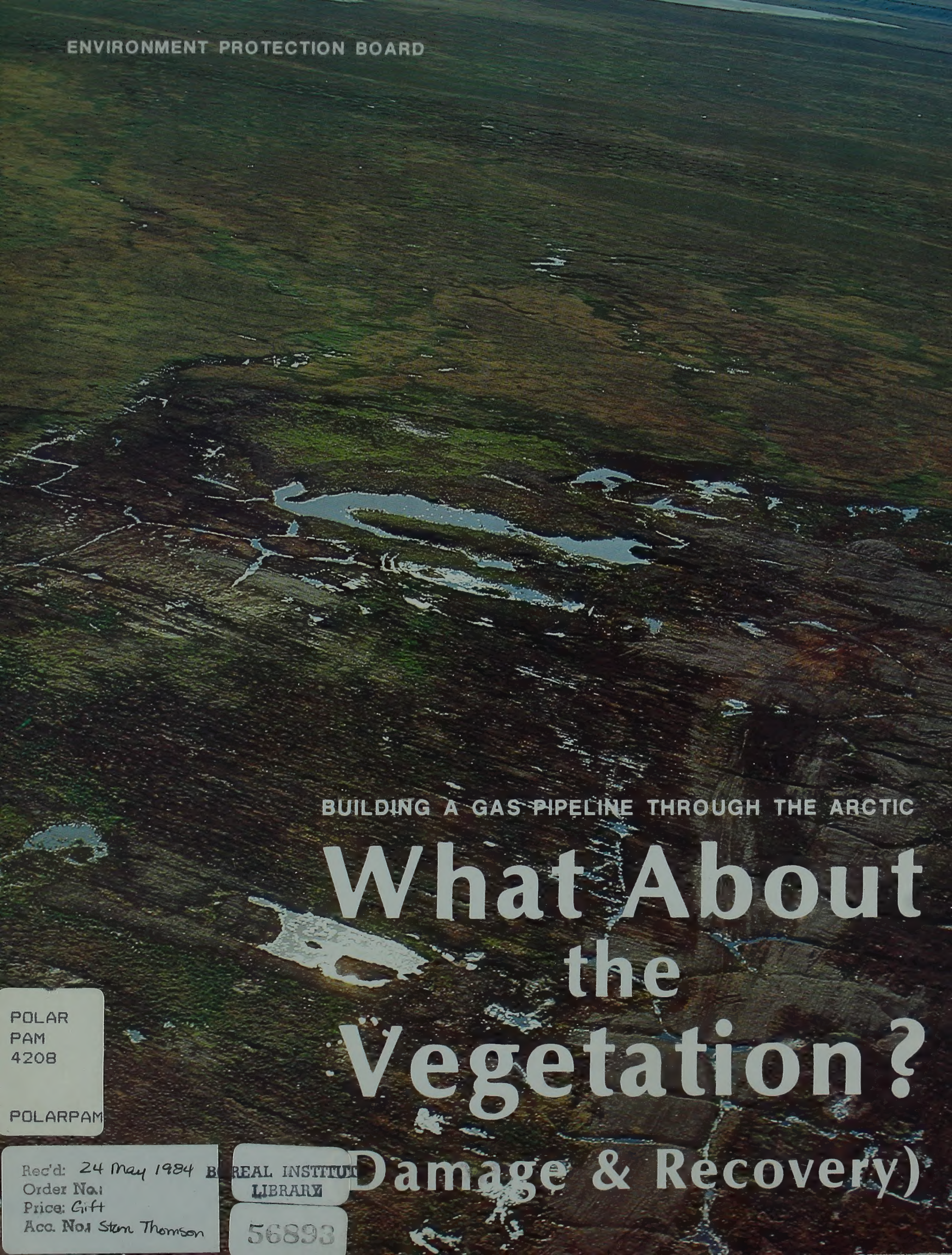

ENVIRONMENT PROTECTION BOARD

BUILDING A GAS PIPELINE THROUGH THE ARCTIC

What About the Vegetation?

(Damage & Recovery)

Vegetation

Four major zones of vegetation would be crossed by the proposed buried chilled gas pipeline along the Mackenzie Valley to the Mackenzie Delta region, N.W.T. and Prudhoe Bay, Alaska. From south to north these major vegetation zones are: (1) the Boreal Forest characterized by closed canopy spruce forests; (2) the Forest-Tundra where spruce forests become more open towards the north; (3) the Alpine Tundra at elevations above the tree line in the mountains; and (4) the Low Arctic Tundra consisting of two units, the Low Shrub-Heath Tundra where low shrubs are the most abundant and visible element, and the Herbaceous Coastal Tundra where sedges comprise the principal ground cover. The location and extent of each zone are shown on the map (inside).

Vegetation is important for two major reasons. First, for animals, it provides food and habitat, either directly or indirectly. Changes in the type of plant cover, therefore, would affect animal populations.

Second, in the North, vegetation insulates underlying permafrost, maintains slope stability and resists soil erosion. Disturbance and removal of the surface layer of mosses and peat exposes soils to more heat from the sun. Summer thaw deepens; ice-rich soils melt; water evaporates, accumulates, or runs off. At best, the ground only settles. At worst, it erodes and slumps, sometimes for several years, occasionally for decades (the site on the photo below is still eroding after 17 years). As a result, the ability of the substrate to support structures is greatly reduced.

J. Hok

Surface Disturbances and Their Effects

Surface disturbances are not recent phenomena in the North. Fires have always been a natural force in the Boreal Forest, Forest-Tundra, and Tundra. Storms and riverbank erosion expose ice-rich permafrost soils, causing deeper thaw and hence slumping, mudslides, and the formation or drainage of lakes. Recently, man's activities have increased both the frequency of disturbance and the amount of disturbed terrain. Disturbance leads to changes in vegetation and, if sufficiently extensive, to changes in animal populations as one type of habitat is replaced by another.

Fire: Fire is the most common and widespread form of disturbance. A natural, and possibly necessary, part of forested areas, it opens up the canopy and leads to a mosaic of forest plant communities of different ages and composition. Some forest species, such as jack pine, require fire before cones will open and disperse their seed. Other species such as grasses, fireweed, and several herbs require fire for the creation of bare soil on which their seedlings can become established. Additional species such as aspen, poplar, and labrador tea can resprout from roots and other unburned underground parts.

The diversity of plant communities which results from fire provides a variety of habitats for animals. Moose feed primarily on the grass-herb-shrub communities which grow on recent burns and thus the moose population may increase in the years after fire, before spruce once again become dominant. Marten, however, depend on the mature spruce forests which fire eliminates.

Fire extends into the Tundra where it also appears to have a rejuvenating effect. However, fire in the Tundra is neither as common nor as widespread as it is in forested regions. This is because in the Tundra, the type of plant cover changes more frequently, there is much less aboveground plant material available for burning, and the surface layer of peat and moss is kept moist by the thawing of the active layer above the permafrost.

Fire in permafrost regions leads to deeper thaw and increased slumping of ice-rich slopes. However, when fire is prevented in some permafrost areas, site deterioration sets in. Litter accumulates and insulates the ground, decreasing the seasonal depth of thaw. This decreases the volume of soil available for plants to root and extract nutrients. As a result, mature forest may be gradually replaced by less diverse, less productive stunted trees or treeless muskeg.

The amount of moisture at a site is a major factor which determines the frequency and spread of fires. In the Mackenzie Valley, closed forests of paper birch or birch-spruce mixtures on exposed, well-drained slopes and uplands burn about every 70 to 100 years; rolling, imperfectly-drained slopes and uplands of closed spruce burn about every 125 years; scattered to closed spruce forests on drainageways, ice-rich soils, or peat deposits burn about every 150 years or more; and fens, bogs, wetlands, and closed forests on river islands seldom, if ever, burn.

Fire can both affect and be affected by the proposed gas pipeline project. Fires that start elsewhere may threaten the pipeline and its facilities during construction and operation. In addition, accidental fires could be started by the project and spread from the right-of-way as a result of construction activities or in the event of a line failure.

Both such types of fires would have to be fought and, therefore, an appropriate fire contingency plan must be available before the project starts. As part of such a plan, the normal pipeline air patrols should provide advance warning of fires. This may increase the number of fires reported and fighting of these fires could result in a decrease of the total area burned.

However, indiscriminate fighting of all fires could be as harmful to existing northern ecosystems as allowing all fires to burn. Because fire is such an important aspect of northern ecosystems the fire contingency plans which are devised should include fire management provisions so that the natural fire frequency is not greatly altered from what it is now, thereby maintaining the existing productive mixture of plant and animal communities.

Construction Activities: Most of the information on the impacts of man on northern ecosystems has come from studies of the effects of petroleum exploration activities. As a result of these activities, seismic lines and winter roads are common in most areas. These trails are conspicuous from the air where trees have been cleared in the Boreal Forest and the Forest-Tundra, including the Mackenzie Delta. In the Low Shrub-Heath-Tundra, seismic lines which before 1966 were surveyed during the summer, have left visible scars. Since 1966, these surveys have largely been restricted to the winter when the ground is frozen and the potential for damage greatly reduced. Seismic line operation has further advanced so that surface disturbance is now generally restricted to some broken shrubs and scuffed hummock tops — a great improvement over the initial summer bulldozing aside of the thawed surface layer of upright vegetation, insulating moss and peat, and mineral soil.

H. Hernandez

Seismic line surveyed the previous winter

H. Hernandez

Seismic line bulldozed 8 summers ago

Petroleum exploration activities, however, have not approached the intensity or level of disturbance which would be required for construction of the proposed gas pipeline.

The proposed gas pipeline and its associated facilities will directly destroy or alter a total of about 50 square miles of land in Alaska, the Yukon, and the Northwest Territories. At permanent structures such as airstrips, compressor stations, communications towers, gravel roads, wharves, camps, and stockpile sites, vegetation will be covered with gravel pads, thus preventing succession. Succession will similarly be extremely slow in borrow pits where rock and gravel are exposed.

Most other construction activities will result in levels of disturbance that should allow vegetation to recover. The ditch-line over the buried pipe will be most severely disturbed, with bare soil at the surface. Watercourse crossings could also be as severely disturbed because some of the riverbanks would have to be cut and graded to meet pipe-bending limitation and provide for vehicle traffic. The remainder of the right-of-way and winter access roads of snow and ice will generally be less severely disturbed, depending on the care with which they are cleared, built, and maintained, the need for grading, and their ability to withstand the required volume and intensity of traffic. Mineral soil will be exposed on various parts of these roads and, in ice-rich terrain, slumping, ponding, and erosion by water are likely.

Erosion of soil as a result of surface disturbance on land can also affect aquatic ecosystems. Adding more soil and organic material to a watercourse than it normally receives can reduce the amount of light reaching the water and thereby reduce production of algae and thus the ability to support zooplankton and fish populations. It can interfere with fish migrations, silt up spawning beds, smother overwintering eggs, and reduce oxygen concentrations. In addition, these effects can reduce the aesthetic quality of a body of water. The potential for additional erosion of exposed soil by water is greatly reduced in the Tundra because summer rainfall is relatively low. Along the Mackenzie Valley, where rainfall is higher, such erosion is a greater problem.

Once disturbances stabilize, the healing process of recolonization commences with the establishment of several "weedy" species, mostly grasses, sedges, herbs, and shrubs. On winter roads and winter seismic lines where roots and rhizomes remained viable following the disturbance, regrowth from these underground parts is also possible.

Although deeper thaw on disturbed sites can lead to slumping and erosion, it also results in warmer soils, a greater soil volume and, in effect, a more favourable soil nutrient status for roots. On stable sites, this enables the established species to grow faster and spread. As they grow and die back each year, litter accumulates and thaw gradually decreases. Predisturbance conditions are eventually approached, although the time required for the entire process to occur in tundra areas is unknown. Grass-dominated communities are known to become established during the first several years after mineral soil is exposed. These communities remain little changed for at least a few decades. Time for recovery of vegetation to the predisturbed communities would probably be of the

Cover photo by H. Hernandez: Four-year-old well site 12 miles south of Shingle Point, Yukon coast. Note recolonization by vegetation (yellow-green) — largely on the less disturbed periphery — some ponding, and settling of gravel along ice-wedge polygon margins.

order of centuries and the scar of peat that was bulldozed aside could probably still be visible.

Cold Buried Pipeline: North of Alberta, the pipeline is to carry gas chilled to below 32ºF. Once the line began to operate, this cooling would also reduce thaw in permafrost areas, thereby improving stability. But it would also have other effects. As frost built up around the pipe and thaw decreased, the depth of the rooting zone, soil temperatures, and the rate and amount of nutrients released would also decrease. The growth of already established plants could be retarded, especially if they proved to be effective insulators. The successful establishment of new plants would also be reduced.

The cold pipe and surrounding frost could also act as a barrier to lateral drainage. Water could be impounded in some areas and diverted in others, depending on topography. Where it was impounded, existing vegetation would be drowned, as has happened along part of the recently con-

H. Hernandez

structed Dempster Highway about 20 miles south of Inuvik. Plant colonization of such sites would be slow. Where water was diverted along the pipeline, erosion of the ditch could reduce the support for the pipe. Both the confinement and diversion of water would decrease the amount of water normally received downslope. Wetlands deprived of their normal amounts of water could dry up, and their vegetation would change. Where this was extensive, the number of animals such a habitat could support would be greatly reduced. The extent of such changes is difficult to predict because of the complex processes involved.

J. Hok

Minimizing Surface Disturbance

Plant communities are much more severely disturbed by equivalent activities in summer than in winter. Wetland communities, for example, are so sensitive to disturbance in summer that one pass of a light vehicle can churn the surface (bottom left). A major way of reducing surface disturbance, therefore, is to restrict as many construction activities as possible to the winter. However, even in winter, upland and lowland communities differ in their susceptibility to disturbance. For the same vehicle traffic, upland low shrub-heath tundra communities have shrubs and other vegetation broken off (background, bottom right), yet lowland wet sedge meadows are not seriously disturbed (foreground, bottom right).

Construction Procedures: Most of the pipeline construction, including trenching and pipelaying, will be restricted to the winter period when the ground is frozen. Many ancillary activities, however, will have to be carried out in summer. These include control, location, and construction surveys, stockpile site construction and receiving of supplies, construction of permanent roads, all aspects of compressor station construction, construction of major river crossings, and various aspects of borrow pit operations. Such summer surface activities must be restricted to fixed sites where gravel pads or permanent roads protect the permafrost.

Winter roads of compacted snow and, where necessary, ice are currently being used and evaluated as a possible way of reducing surface disturbance. They have been used in the Low Shrub-Heath Tundra to supply drilling rigs from base camps. Shrubs are generally removed and the peat generally remains intact but thaw is also deeper. These roads, however, have not been subjected to the large number and frequency of passes proposed for pipeline construction. Near Norman Wells, a test loop on relatively level ground over moderate ice-content soils with gravels was tested with the expected traffic. Little mineral soil was exposed; thaw was deeper, and some vegetation resprouted from viable roots and rhizomes.

Where winter roads are used, they must be constructed carefully and maintained properly. Misuse of winter roads by extending traffic too late into the spring after thaw has begun, or starting too early in autumn before the ground is frozen, results in effects almost as severe as in summer. Although the

L.C. Bliss

ground is frozen, indiscriminate overland off-road travel in winter must be prevented to reduce the area disturbed.

Construction in forested areas will require clearing of trees and brush. Where slash is burned, it will have to be done on burning sleds or on ground that is to be more severely disturbed such as by ditching, since burning slash directly on the ground in winter also results in burning up to 8 inches of insulating peat.

If emergencies arise in summer, repairs may require overland travel on thawed ground. Low ground-pressure vehicles are able to cross low-shrub-heath tundra communities safely a few times. If wet sedge communities have to be crossed, however, they will be greatly disturbed.

Revegetation/Restoration: The possibility of speeding up the establishment of a stabilizing plant cover on disturbed areas in the North has been investigated by U.S. and Canadian Government groups, Canadian Arctic Gas Study Limited (CAGSL), oil companies, universities, and this Board. The Board has been directly involved with sites near Norman Wells, Inuvik and Tuktoyaktuk, N.W.T. and Prudhoe Bay, Alaska. Reports from sites throughout interior and northern Alaska and from CAGSL sites at Prudhoe Bay and Sans Sault, 50 miles north of Norman Wells, have also been made available.

Other investigations have provided information on the sensitivity of different plant communities to various types of disturbance, on the kinds of plants that colonize disturbed sites, on the patterns of recolonization, and on the time required for recolonization. Related studies and trials have provided data on suitable construction procedures to reduce some of the effects of construction on vegetation and terrain. And other studies and tests have pointed out possible techniques which can be used to help establish a plant cover on some disturbed sites.

In the Tundra, plant species most successful in establishing on disturbed sites and overwintering include northern-adapted varieties of several grass species and two native grasses which are the most common colonizers of disturbed sites, bluejoint *(Calamagrostis canadensis)* and polar grass *(Arctagrostis latifolia)*. More species prove successful in the more favourable environments of the Forest-Tundra and the Boreal Forest to the south.

Rather than relying on the most successful species, investigators are examining mixes of those species which have proven most effective over a range of environmental conditions. Using a mix of species would reduce the possibility of failure as a result of disease or harsh environment. Such a mix could be prepared for each of the vegetation zones crossed by the proposed pipeline and could be applied over a wide area by aircraft.

Currently, seed is being developed from the two best native species, polar grass and bluejoint. They are to be included in the seed mixes to be used, especially in the northernmost regions. This may improve their chances of taking over from the other seeded species. Indications are that the species being tested are not replacing the native species in undisturbed communities. These and other weedy species, however, are able to maintain themselves in disturbed sites, such as around townsites and roadsides.

Re-establishment of a plant cover by both natural recolonization and seeding has proven more successful in areas of exposed mineral soil than on peat and gravel sites.

Water availability and precipitation greatly affect the success of establishment. During wet summers of normal length, plant establishment and growth of both native and seeded species are much greater than during dry or short summers. In all areas, but especially in the Tundra because of the generally low rainfall, seeding must be done in the early spring to take advantage of the snowmelt.

A total of 30 to 60 pounds/acre of seed is generally needed to obtain a near complete ground cover under the most favourable conditions. Fertilizer is needed for the best results, the most important elements being nitrogen and phosphorus, although others such as potassium have proven useful. Levels of about 100 to 200 pounds per acres of each element seem to be the best, and refertilization in the second year also enhances growth.

The lush vegetation on fertilized plots is higher in nutrients than the native undisturbed vegetation and hence is attractive to various grazing animals, such as caribou which grazed on the clump of grass shown in the photo below. In other test areas,

H. Hernandez

hares have similarly grazed on the new growth and birds have eaten the seed before it could germinate. Thus the effectiveness of a revegetation program may be reduced, especially where large populations of herbivores come in contact with it.

Reseeding and reestablishment of a plant cover on disturbed sites will prevent neither deeper thaw nor melting of near-surface ice since most of the insulative properties of vegetation comes from the mat of peat and living moss. Thus, reseeding will not control erosion of unstable sites and vegetation will not establish to any great extent until such sites have stabilized. Additional measures will, therefore, have to be developed to help stabilize these slopes. Staked pre-seeded mats may prove useful on sites which are not subject to high rates of erosion. Staking these mats with cuttings of willow and other shrubs which can resprout may help the revegetation process.

The proposed gas pipeline raises many questions. These include questions on the effects of higher levels of disturbance, on the role and sequence of plant succession in northern ecosystems, on the effects of these changes on animal populations, on the long-term impacts on both terrestrial and aquatic ecosystems of using fertilizers, and on the effectiveness of reseeding as compared to natural plant establishment.

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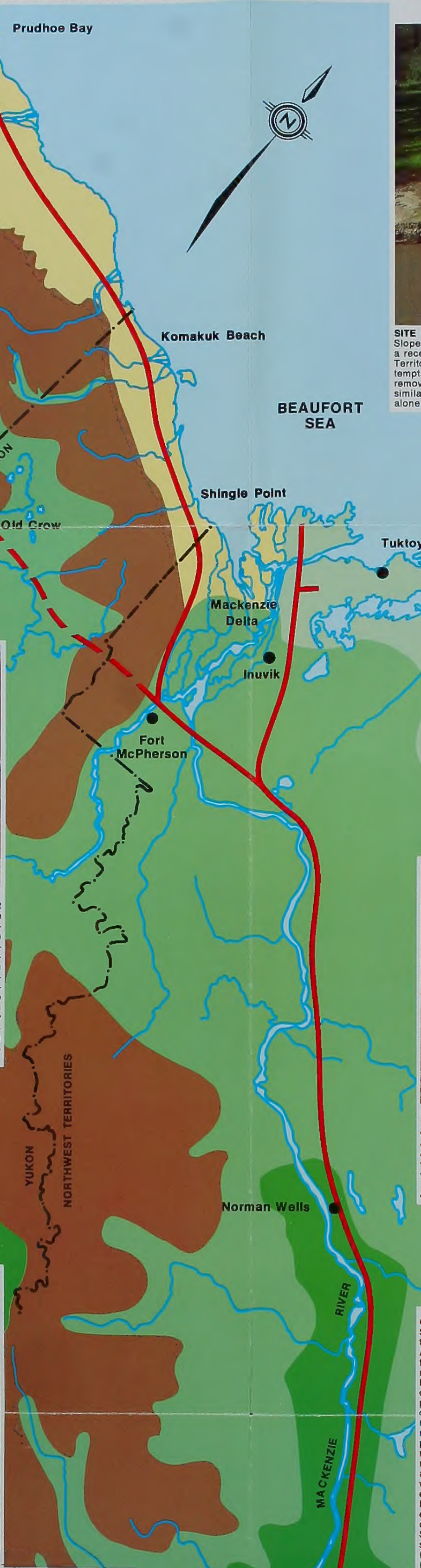
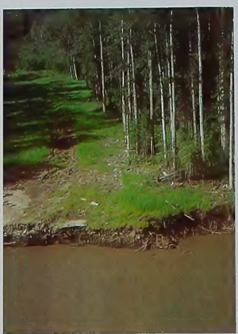
NATURAL RECOVERY
These photos form a sequence showing natural plant recolonization for the first three years on the same stable seismic line in the Mackenzie Delta west of Inuvik. The line was cleared through a mature white spruce-willow-alder community. Total live plant cover on the line was less than 2 percent in the first summer (left). This had increased to about 21 percent in the second summer (centre) as willows and other shrubs sprouted from viable roots and a few species not present in the undisturbed community had become established. By the third summer (right) plant cover had increased to 67 percent including regrowth from mosses and expansion of previously established clumps of shrub and grass. All sites are not necessarily as stable as the above. On slopes, erosion may occur, thereby retarding plant establishment.

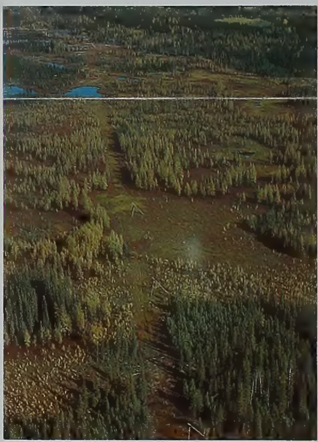




L.D. Doran

L.D. Doran

SITE STABILITY
Slope and surface stability greatly affect the success of reseeding programs as can be seen along portions of a recently constructed gas pipeline in the vicinity of the junction of the Yukon-British Columbia-Northwest Territories boundaries. The gas in this pipeline is warm, not chilled. On level, stable sites (left) revegetation attempts are generally successful. On slopes, even where soils have low ice contents (right), water erosion can remove surface soil along with seed and newly germinated seedlings. These and other exposed sites may similarly be subjected to wind erosion, which also reduces the success of revegetation programs. Reseeding alone will not, therefore, prevent erosion. Other techniques will have to be developed to help control it.



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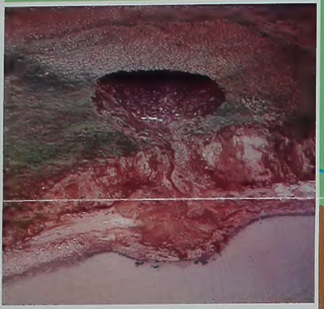

R.B. Read

H. Hernandez

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NATURAL DISTURBANCE
The high ice content of many permafrost soils is a major reason for concern about disturbance. Natural disturbance of the insulating cover of vegetation can expose the underlying ice whether it be in the form of ice wedges (bottom left) or ice lenses (bottom right). Once exposed, the ice melts, the water and silt flow down-slope and, with the loss of support, the overhanging vegetation also falls down, often creating a bowl-shaped depression (top). Although this slumped material can help insulate the exposure, it often is of insufficient volume to be effective, thus exposing any ice which remains and expanding the area affected. If such exposures occur as a result of construction, not only would the terrain be degraded but the ability of the ground to support structures such as the pipeline would also be greatly reduced. In addition, the material which flows downslope generally enters a watercourse, thereby affecting aquatic ecosystems. Adding more silt and organic material than a watercourse usually receives can reduce the amount of light reaching the water and thereby reduce production of algae and thus the ability to support zooplankton and fish populations. It can also interfere with fish migrations, silt up spawning beds, smother overwintering eggs and reduce oxygen concentrations.

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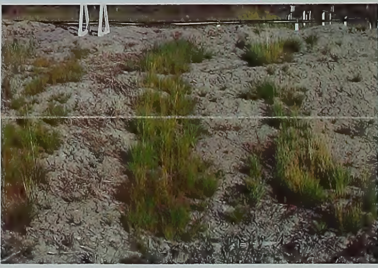
R.B. Read

SEVERITY OF DISTURBANCE
Even in winter the severity of disturbance varies with topography and the type of vegetation. Low, flat, wet communities on low ice content soils can be cleared and travelled in winter with little surface damage resulting, as can be seen on the tamarack sedge wetland crossed by the telephone line and access winter roads (top). On other flat sites where soils are ice-rich, similar winter disturbances can lead to melting of the ice, settling of the ground, and ponding on these depressions (bottom left) since the water is unable to flow away. On more rolling terrain (bottom right), winter disturbance can remove the insulating surface moss and peat, expose underlying frozen soils with resultant thawing, slumping, and erosion.

I. Powick

COLD PIPE
Since the gas will be chilled to below 32°F north of Alberta, this cooling will affect the success of revegetation. Once the line began operating, thaw depth would decrease, improving stability. But this decrease in thaw would also restrict the depth of the rooting zone, lower soil temperatures, and reduce the rate and amount of nutrients released. The growth of already established plants would be retarded, especially if they proved to be effective insulators. The establishment of new plants could also be reduced. Some of these effects are shown for a 15°F cold pipe (top) and a 65°F warm pipe (bottom) at test sites near Norman Wells. Fewer species survived over the cold pipe, as indicated by the gaps between rows where species have died out. Growth and production of flowers and viable seed of surviving species were not as great after 1 winter and 2 summers. For example, clover, alfalfa, and several grasses grew best and flowered extensively over the warm pipe, were somewhat less successful on other test plots where no pipe was present, but were limited to a few individuals of each species over the cold pipe.



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L.C. Bliss

L.C. Bliss

FIRE
Fire (top), the most common and extensive form of natural disturbance in northern regions, is a normal, and possibly necessary, aspect of forested and tundra areas. With the burning of the vegetation, the forest canopy is opened and seasonal thaw of the active layer is usually greater. Some plants regenerate from unburned rootstocks and others establish on the exposed soil. The bottom sequence shows the recovery in the first (left) and third (right) summers after a fire burned the open spruce forest-tundra community near Inuvik. It is important to try and maintain the natural fire frequency to preserve the existing productive mixture of successional plant and animal communities. Appropriate fire contingency plans, therefore, will have to be developed to protect both the pipeline from external fires and the forests from fires caused by pipeline-related activities.

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VEGETATION: DAMAGE & RECOVERY
The proposed gas pipeline from Prudhoe Bay, Alaska and the Mackenzie Delta area, N.W.T. to Alberta would cross four major zones of vegetation. Their location and extent are shown on the map above. In all zones, establishment and growth of plants require stable sites with adequate soil moisture, nutrients and temperatures. In addition rainfall must be sufficient to permit germination of seeds and spores, and continued growth and development of roots and shoots. Plant establishment and growth, however, are retarded on unstable sites, in regions of strong winds, where rainstorms are frequent, or where soils are cold, low in nutrients and poorly developed.

The Low Arctic Tundra is one of the most sensitive regions to disturbance because it has the shortest growing season, coolest climate, low plant biomass and it contains extensive areas of high ice content soils, especially along the Arctic coast. As a result, the possibility of slumping and erosion following disturbance is high, natural plant recovery is slow and revegetation attempts are less successful since only a few species can survive.

The vegetation of Alpine Tundra areas is equally sensitive to disturbance. Plant recovery and revegetation are generally slow because of the exposure of mountain slopes to wind action and because of poor soil development. However, since bedrock is near the surface and soil ice contents are low, the possibility of erosion as a result of ice melting is reduced.

In the Forest-Tundra, the climate is more favourable than in the Tundra. Since rainfall is higher, the possibility of erosion by water is increased. However, the generally lower ice contents of soils helps reduce the possibility of mass movements. Plant recovery here is generally faster and more seeded species survive than on the Tundra.

The Boreal Forest has the most favourable climate. Recovery and reseeding are thus the fastest of the four zones crossed by the proposed pipeline. However, portions of the banks of the Mackenzie and other rivers are known to slump and special techniques may be needed to control erosion here.

LEGEND

- BOREAL FOREST
- FOREST-TUNDRA
- ALPINE TUNDRA
- LOW ARCTIC TUNDRA
  - *Herbaceous Coastal Tundra*
  - *Low Shrub-Heath Tundra*
- PIPELINE ROUTES
  - *Proposed Prime Route*
  - *Proposed Interior Alternate Route*
- BOUNDARIES

REVEGETATION
Investigations on methods of speeding up the establishment of a plant cover on disturbed sites in the North have been carried out since 1970. Growth and success are easiest and greatest in the south and decrease towards the north as a result of cooler climate, lower precipitation, and shorter growing season. The agronomic species which can overwinter successfully and continue to grow are now known, as are the native species which colonize disturbed sites. These species include two grasses which are being cultivated in attempts to obtain enough seed for use in reseeding programs. Fertilizer must be used for best results. Generally, use of mixes of several species should prove the best for a wide range of conditions within each vegetation zone.

The stability of the site greatly affects the success of reseeding. Level sites where mineral soil is at the surface are most easily revegetated. Natural succession by several native species of grasses, herbs, and shrubs combined can result in an almost complete plant cover within 8 to 10 years on stable sites. In comparison, reseeding similar sites with the best varieties of northern-adapted grasses has yielded nearly complete cover within 1 to 3 years where moisture and other site conditions were most favourable and when the seed was sown in small experimental plots (left). Broadcast seeding of larger areas (right) requires a few more years to obtain comparable cover. And cool or dry summers retard plant establishment and growth.

Although successful revegetation requires suitable physical site conditions of stability and moisture, along with a favourable climate, other natural forces also affect its success. Birds have eaten seed sown on some test plots. Caribou, hares, and other herbivores have been attracted to and grazed on the lush and more nutrient-rich growth on fertilized test sites, thereby reducing the effectiveness of revegetation.

Environment Protection Board

In 1970 the Environment Protection Board began studying effects on the natural environment of construction and operation of a natural gas pipeline through the Yukon and Northwest Territories. The study involves collecting baseline data, incorporating environmental planning into pipeline design, assessing impact, preparing guidelines for education and control of construction personnel and evaluating post-construction activities. The Board, now sponsored by Canadian Arctic Gas Study Limited, is composed of specialists in Arctic research or environmental science.

The Board, an autonomous body, is guided by the following objectives:

1) To become sufficiently familiar with arctic ecosystems in the area of pipeline operation to permit estimates of biological costs or benefits of construction and judgments about the potential for widespread damage or major disruption of ecosystems.

2) To become sufficiently familiar with biological and physical environments so that pre-construction findings can be used as a basis for post-construction evaluation.

3) To make recommendations and conduct briefings so that results of the Board's deliberations can be used for maximum environmental protection.

4) To make available results of its studies as a direct contribution toward northern scientific development.

The Board's deliberations are to continue throughout the life of the proposed four-year construction project and for a suitable period during the operational phase.

Members of the Environment Protection Board are: Mr. C.H. Templeton (Chairman), Dr. L.C. Bliss, Dr. M.E. Britton, Mr. D.W. Craik, Mr. E. Gourdeau, Dr. I. McTaggart-Cowan, Dr. S. Thomson, Dr. N.J. Wilimovsky and Mr. R.C. Isaak (Secretary).

Outside specialists are used for specific assignments. Administrative support for the Board is supplied by Interdisciplinary Systems Ltd., 528 St. James Street, Winnipeg, Manitoba.

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